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A1 ASSUMPTION

The following programme description of the IOCP “En-Route Multi Sector Planning Procedures” describes the next two years’ programme. During 1995, a first experiment was performed. Results of this experiment can be found in the Report on the first Prototyping Experiment Run (Ref: PHARE/EEC/PD3-2.1/REP_01;1). This baseline and results will be used for following programme.

A2 SUBJECT DESCRIPTION

En-route Multi Sector Planning is one of the key issues to be investigated by PD/3 as a means of improving air traffic flow management capacity. The objective of this IOCP is to validate the roles of air traffic controllers in the context of Multi Sector Planning and the associated ATC procedures and tools which they should use, based on the organisations proposed by the Operational Task Force. Use will be made of prototyping to carry out this validation. The resulting specifications will be an important input into the specification of the PD/3 Demonstration Facility and the PD/3 experiments themselves.

The scope of this work is as follows:

1. Definition of the ATM functions and the role which will be required in a Multi Sector Planning environment, based on the organisation proposed by the Operational Task Force.
2. Definition of tasks to be performed for the role.
3. Definition of procedures to perform for each of these tasks.
4. Dimensioning of multi-sectors.
5. Identification of tools and their use required to support these tasks.

Some initial work on En-route Multi Sector Planning procedures has already been initiated outside the context of PD/3. In particular, the work on this IOCP will take into account the alternative concept of Multi Sector Planning developed for EATMS simulations conducted at EEC.

The IOCP will also take into account the HMI work done by the GHMI group for other PHARE Demonstrations and for PD/3, although there are clearly difficulties in doing so given the timescales concerned.

This IOCP will perform prototyping experiments using facilities available at the EEC. The work uses the dimensioning studies for making initial assessments of sectorization plans for the PD/3 experiments.

A3 OPERATIONAL CONTEXT

The concept of "En-route Multi Sector Planning" has been put forward within the ATM community as a means of increasing the capacity of air traffic control systems to accommodate the growth in air traffic.

The concept may be characterised in broad terms as follows. Until recently tactical planning for air traffic management has been on the relatively short-term timescale of “a few minutes ahead of the current time” and has concentrated on smoothing traffic flow within a given sector. Multi Sector Planning seeks to shorten traffic deconflicting and increase airspace capacity : possible means are by the organisation of short/medium-term traffic flows on a somewhat larger scale, spanning several sectors or even centres.

This approach to ATM is likely to involve the introduction of new air traffic management functions, roles and tasks. For example, additional levels of ATM supervision may be introduced to carry out “look-ahead” to manage traffic flow over the next few sectors. Roles might include a Multi Sector Planning controller who would have access to strategic actions to manage congestion, such as flight level allocations, speed constraints and offsetting aircraft groups, leaving sector planners to resolve tactical issues. The concept in Operational Organization is likely to require dynamic look-ahead into the next centre’s plans for future air traffic flow and to interact with that traffic flow in order to smooth traffic distribution and complexity.

To achieve the objective, the concept may be employed in a dynamic and flexible way to respond to relatively short-term changes in demand for airspace. For example, it might be applied selectively to traffic flows along major axes and would change in response to the dynamic flows.

A further requirement will be to ensure that any new functions and role are efficiently integrated within the system. The concept could lead to a significant reallocation of tasks and responsibilities if this proves to be the most effective way of achieving higher capacity.

The IOCP should take into consideration the technological factors affecting the concept. These parameters are:

1. degree of applicability of ground prediction (meteo, aircraft modelling) to non-4D equipped aircraft
2. better use of operational flight plans could be made to increase prediction accuracy (e.g. knowledge of operation rules, type of aircraft, weight etc.)
3. influence of quality of meteorological data

4. the application of new support tools, such as Look Ahead and Tactical Load Smoother functions and their influence on the awareness of traffic complexity
5. employment of 4D flight management systems and air-ground data-links for timely exchange of data.

A4 APPROACH AND METHOD TO CONDUCT THE IOCP

The specifications shall follow a structured task analysis approach, considering each of the controller tasks in turn, including defining the information requirements and information transformations performed. They will also provide definitions of data formats, presentation and the role and functionality of support tools.

In parallel with this activity, the means and criteria for measurement of the proposed solutions will be specified.

The traffic scenarios will also be considered at this stage since these could have important effects on the results and hence the conclusions of the studies.

Several prototyping experiments (taking into account results obtained by previous experiments) will be carried out during the IOCP studies in order to test and to build up the concept of En-route Multi Sector Planning within the Operational Organisation approach. This will require operational expertise as well as prototyping expertise and HMI advice to conduct experiments.

A5 FACILITY OUTLINE DESCRIPTION




The full definition of the simulation environment required to test the procedures will depend on the specifications of the En-route Multi Sector Planning procedures, since the procedures will determine the tasks and functions to be examined experimentally. At this stage it appears that the facility shall provide an ATC ground system simulation oriented at HMI evaluation but including at least a minimal representation of air-ground data-links and 4D FMS equipped aircraft. The rapid prototyping facility will comprise several working positions simulating adjacent sectors and centres. It should permit investigation of the procedures for integration of adjacent sectors/centres, and also the integration of ATM roles within centres.

The use of a dedicated HMI (based on PD/1 HMI) to test procedures will permit various formats and presentations to be examined. It is important that these are well specified and defined well in advance to benefit the HMI design for the full PD/3 experiments.



Facilities will be: first step, the EEC's Rapid Prototyping Facility and, second step the final demonstration platform. The facility requires multiple controller working positions with 19" and Sony displays.

A6 DEPENDENCIES

Achievement of the objectives depends critically on the following:

-  Timely availability of the Operational Task Force output defining Multi Sector Planning concept.
-  Adequate availability of assessment platform(s) to investigate procedures.
-  Ease of modification of assessment platform to provide a basis for investigating the different procedures in the required time-scale.

The work will also depend on the other IOCPs :

-  ETMA/En-route interface
-  Human centred approach, Co-operative tools

A7 REFERENCES

- [1] PD/3 Initial Operational Scenarios Description. Draft dated March 1996.

Annex B: HUMAN CENTRED APPROACH

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B.1 SUBJECT DESCRIPTION

This section will define the Human Centred Approach very briefly and place this IOCP in the context of PD/3 and other PHARE projects.

Following the review of the PD/3 Demonstration early in 1996, the Human Centred Approach concept was retained in the advanced scenario for PD/3, and is described in the Operational Scenario Document. It has also been stressed that this IOCP programme should contribute directly towards the preparation for the final demonstration, and in this respect both the operational and technical aspects will be taken into account.

This concept aims at providing tools which fit the controller's cognitive process and enables them to improve their effectiveness, retain their decision-making ability as well as responsibility in an operational scenario. It does not prevent the introduction of new working methods or task sharing within the team of controllers if this should be required.

In order to achieve this, the following main principles of the Human Centred Approach will be applied during the design and development processes of this IOCP and during the preparation for the final demonstration:

(1) Keeping the human in the loop

It is intended to keep the human in the loop, not only at the level of tools' usage but also during all the design phases of the PD/3 advanced organisation, ranging from operational scenario to detailed specifications.

(2) Providing problem driven assistance

Assistance will take the form of a two-part approach. Firstly, to address the bottlenecks of the present controllers' activity (memorisation, information filtering...). The support provided by the tools should take these bottlenecks into account, try to make up for them, and, at the very least, not make them worse. Doing so, we start from these bottlenecks, which are the problems to solve, and use them as a guideline to decide how to use tools' benefits and how to design new working methods. This is what is meant by a "problem driven" approach, as opposed to a "technical driven" one, which would only try to answer the question "how can we make the controllers use the output of our tools?". Secondly, and as a consequence of the first point, information and dialogue facilities provided by the tools must relate easily to "control problems" (conflict situations) around which controllers' activity structures itself.

B.1.1 Objectives of this IOCP

As the Human Centred Approach is based on knowledge of the controller's cognitive mechanism, its benefits will firstly be evaluated in that context. An assessment will be made of its ability to improve the following areas:

- ☞ **Increased scope of planning and anticipation activity** (with Multi-Sector Planning as a possible continuation);
- ☞ **Air-ground trajectory negotiation** (enhanced common and accurate representation of a flight/trajectory);
- ☞ **Integration of Departure and En-Route traffic management.**

Therefore, the current objective of this IOCP is to provide input to the sector control position specification to be evaluated during the final demonstration of PD/3, with emphasis on the teamwork aspect, the transfer and change of responsibility resulting from new working procedures and impact on the controller's performance.

The IOCPs form an iterative and incremental process, providing in the following areas:

- ☞ **Roles and tasks of the planning and tactical controllers**, particularly the limits between "traffic organisation philosophy" and "pure 4D conflict free". Major focus points for investigation will be : problem driven approach, 3D/4D mix, anticipation, team work and aircraft monitoring ;
- ☞ **HMI specifications and tools behaviour.**

The geographical scope of the IOCPs is in line with the work-sharing decision made between PD/3 partners. It covers the En-Route sector and TMA departure traffic positions; i.e. from take-off to cruise level.

B.1.2 Requirements

The following tasks and facilities will be required in order to adapt cognitive engineering principles in the context of PD/3 and to evaluate impact. This includes the incremental adaptation of the simulation facilities.

The study of the controller's activity has led to the definition of four main groups of support facilities:

- information filtering,
- memory and surveillance aids,
- mental resource management ,
- inter-controller co-operation aid.




Requirements for a set of tools capable of responding to these support needs has already been established. A prototype now needs to be developed which will support the major PD/3 Demonstration objectives:

- (a) **Evaluation of the operational impacts of the HCA:** the prototype integrated in the PD/3 environment (and thus interfaced with other PHARE components) will be evaluated through criteria and evaluation tools in co-ordination with the VAL group ;
- (b) **Integration with the PHARE designed HMI:** the simulation prototype used during the evaluation phases of the IOCP will be compliant with the requirements produced by the PD/3 GHMI Design Team, so as to provide a feedback on the specifications at each phase of the IOCP;
- (c) **Consolidation of teamwork, including intra and inter-sector co-ordination:** mainly, enlarging the aids to intra and inter-sector co-ordination activities and areas of common responsibilities. This will be an enhancement of several aid functions, and particularly the co-operation aid within an advanced planning environment ;
- (d) **Consolidation of the interface between Departure and En-Route:** this will be based on enhancing data information exchange procedure between En-Route and Departure sectors and refining working methods that will enable ATCOs to benefit from these data ;
- (e) **Definition of aids in a Multi-Sector Planning context:** this will be determined by the specific Multi-Sector Planning requirements as depicted in the Operational Scenario document and consolidated during the IOCP Multi Sector Planning ;
- (f) **Consolidation of the integration with services provided by PATs and CMS** (including services obtained by connection to other demonstrators, e.g. : down linked aircraft parameters) ;


B.2 OPERATIONAL CONTEXT

The operational context will be derived from the Operational Scenario document. Some specific points can be mentioned here that are important to this IOCP:

B.2.1 ATM/ATC




-  Airspace : this IOCP will cover Departure areas, ETMA and En-Route airspace ;
-  Sectorisation : the target airspace is part of the French airspace between Charles de Gaulle airport and Maastricht ACC. No major changes from today's situation are anticipated, except the use of offset and published direct routings ;
-  Task sharing : The role and tasks of the controllers of different sectors will be based on the OSD description. Results from the IOCP programme will be used to adapt the task sharing for the final demonstrations.

B.2.2 Traffic

-  The tools should be designed to cope with the 2 aircraft classes : 4DEFMS data-link, and 3DFMS non data-link.



B.2.3 Technical performance

In order to avoid negative influence on the use of the tools, the following elements must be specified adequately:

-  surveillance data accuracy ;
-  flight plan and trajectory data accuracy and lead time ;
-  communication equipment performances.

B.3 APPROACH AND METHOD OF CONDUCTING THIS IOCP

The main features of the approach are :


-  to be driven by a preliminary study of the controller's activity ;
-  to involve the controller at every step of the design.

The PATs project has produced a set of requirements from its initial work in this context and has identified the tasks needed to produce the concept of co-operative tools in both the technical and operational areas of the PHARE scenarios. Results from other advanced tool research (such as Trajectory Predictor, Flight Path Monitoring, Conflict Probe, Negotiation Manager , that meet the requirements for more “system oriented” functions, will also be incorporated.

The main purpose of the following section is to outline the evaluation method that will be used, based on a series of experiments supported by incremental versions of the test-bed.

B.3.1 Evaluation issues and environment

The evaluation issues and the associated prototype must be :

-  comprehensive enough to be representative of the tools defined in the PHARE project;

- ✎ relevant to the PD/3 advanced organisation, so as to be able to:
 - ✎ define the electronic support needed in the context of anticipated planning and enhanced G/G A/G co-ordination ;
 - ✎ assess the impact of DM and HCA tools on inter and intra-sector task sharing ;
 - ✎ anticipate the definition of the use of co-operative tools in a multi-sector-planning context.

Moreover, as the PATs CT and DM will be demonstrated for the first time in PD/3, collaborative tasks with GHMI and VAL external projects must be identified. These tasks will aim at participating in the definition of PD/3 HMI and testing facilities so as to ensure their consistency with the approach; the main emphasis will be on :

- ✎ integration of the HMI and of the internal logic of the tools ;
- ✎ defining the criteria and the tools for the evaluation of the operational impact ;
- ✎ defining and achieving test tasks at every stage of the tools design and development. The precise definition of these tasks should reuse as much as possible the definitions developed for PD/1 and PD/2 as well as for PD/3 globally.

The precise definition of these tasks will be developed in close co-ordination with GHMI and VAL groups.

The prototype finally resulting from the IOCP programme will be functionally close to the one being requested for the PD/3 facility test integration.

B.3.2 Step by step approach of HCA

The IOCP project organisation has two major evaluation activities with the following objectives:

- (1) Evaluation of Version 1 of the sector Planning Controller position in an En-Route environment, by testing the use of co-operative tools in the context of enhanced inter-sector co-ordination (this will be done in two steps)
- (2) Evaluation of Version 2 of the sector Planning Controller position in an integrated TMA Departure En-Route environment. The detailed description of the corresponding versions of the prototype will be described in specific project documents.


B.4 FACILITY OUTLINE DESCRIPTION

B.4.1 Airspace description

1. There is a need for two adjacent En-Route sectors for IOCP Step 1 .
There is also a need for one departure, one ETMA and one En-route sector for IOCP Step 2;
In addition to airspace structure data that are commonly used at least for trajectory prediction, extra attention must be paid to the description of the airspace at the fringe of two En-Route sectors ("airspace" must be read as "all data supporting co-ordination" (letter of agreement ...)). This is a prerequisite to the simulation of Multi Sector Planning, that is also related to the notion of "airspace of interest for one flight".
2. Description of airports : it is necessary to describe Roissy airport in the context of a realistic environment in the scenarios in order to evaluate the concepts in different phases of flight from take-off to cruise level.

B.4.2 Co-operation with other PHARE groups and Software environment

1. GHMI : The GHMI interface used in the Controller working position should be sufficiently sophisticated to support the complex tools demonstrated in the HCA IOCP.
2. VAL : the validation criteria and protocols defined for PD/1 and PD/2 will be used as a basis.
3. CMS : some work will have to be done to ensure the compliance of the following services with the requirements of this IOCP :
 - ✎ Airspace ;
 - ✎ Monitoring ;
 - ✎ Sectorisation / Operational configuration ;
 - ✎ Co-ordination.
4. PATN : some work will have to be done to ensure the compliance of the integration of data with the requirements of this IOCP.
5. EFMS : some work will have to be done to ensure the compliance of the integration of data with the requirements of this IOCP.
6. PATs : All PATs will be integrated in the PD/3 environment. During this IOCP, particular attention will be given on the integration of the Co-operative Tools and Departure Manager with the other PATs :
 - ✎ Trajectory Predictor ;
 - ✎ Flight Path Monitor ;
 - ✎ Conflict Probe ;
 - ✎ Negotiation Manager ;
 - ✎ Problem Solver ;

 Arrival Manager.

7. To conclude, some extra requirements or modifications to the PHARE tools may result from the evaluations carried out during this IOCP.

B.4.3 Working Positions






In a first analysis, Two En-Route sectors and one Departure position are needed to carry out the IOCP programme.

The experimental configuration to be adopted will be detailed in the experiment plan associated with each evaluation step.

B.4.4 Physical organisation

The communication performances provided by the hardware and communication equipment chosen must be known early enough, as they will influence the design of functions for which the response time is a prevailing criteria.

B.5 DEPENDENCIES

-  results of intermediate internal studies (e.g. co-ordination aids, common Air/Ground representation of the flight) ;
-  integration of other PATs : TP, NM, CP ;
-  intermediate outputs from other IOCPs (Multi-Sector Planning tasks and procedure definition, final choice on the degree of functional coupling between AM and DM) ;
-  flight processing functions enhancement (CMS) ;
-  HMI version availability.

Annex C: EN-ROUTE/ETMA INTERFACE

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C.1 INTRODUCTION

This document gives a description of the IOCP "ETMA/En-Route interface". The IOCP started at the end of 1995. Since that date, the main activity has been the system's adaptation and the analysis of the IOCP investigation options. The outcome of the investigation options indicated that the focus would be laid on the analysis of new communication and co-ordination procedures by Planner Controllers of the sectors involved in a given arrival stream. The arrival stream to be investigated will be the south inbound air-traffic.

C.2 SUBJECT DESCRIPTION

The interaction between the ETMA and En-Route sectors is one of the key-issues to be investigated by PD/3. This IOCP will test the handling of traffic in relation to this interaction between En-Route and ETMA. It combines the fields separately covered by PD/1 (En-Route) and PD/2 (ETMA). The IOCP will mainly concern the procedures but also the tools to be used. A general description of the procedures has been provided in the PD/3 Demonstration Operational Specification (OPS). An initial detailed refinement of the operational procedures have been presented in the draft PD/3 Operational Scenario (OSD). Both documents have been produced by the PD/3 Operational Task Force (OTF). These descriptions will be worked out in more detail within the context of this IOCP.

C.2.1 Scope of this IOCP

The general scope of this IOCP is the integration of the PHARE Advanced Tools (PATs) with new operational concepts (such as multi-sector planning and 4D-negotiation).

This introduction will have consequences on the operational procedures. This IOCP will research the effects of these new procedures, especially in the area between the ETMA and the En-Route sectors. Following this research these procedures will be tested and, if necessary, will be revised.

The co-operation between tools in different sectors needs careful attention in order to prevent negative effects on the desired increase in capacity and safety. Whereas this appropriate co-operation between the various PATs involved should be guaranteed by the PATs project, it will be necessary to investigate whether these tools as a whole support the defined operational procedures.

C.2.2 Objective of this IOCP

The objective of this IOCP is to evaluate and refine the description of the tasks and procedures of the ATCOs in the particular sectors of the ETMA airspace and the description of the requirements of the tools to be used. These tasks and procedures will be tested by means of a real-time simulation.

C.3 OPERATIONAL CONTEXT

Initially the operational concepts documented in the OPS [1] will be reviewed and, in agreement with the OTF, a number of options will be identified for further analysis and investigation.

The options selected for investigation are:

- co-ordination procedures between the En-route, ACC and TMA controllers
- appropriate co-operation between the PATs, namely AM, CP, FPM, HIPS, NM and TP
- study of the feasibility of continuation of 4D-negotiation within the ETMA area
- study of the feasibility of extension of the En-Route multi sector planning procedures to be used at the ETMA/En-Route boundary and within the ETMA

Two IOCP experiments will be performed preceding the PD/3 experiment. The first IOCP experiment will focus on the first two options, whereas the second one will address all options.

C.3.1 Sector Definition

C.3.1.1 ETMA

The ETMA airspace, which will be used in this IOCP, must be defined. As described in the OPS document [1], the ETMA covers the Approach sectors and the ACC terminal sectors dealing with the descending and climbing traffic to and from the concerned airports.

ETMA airspace thus covers two types of sectors. Firstly, the Approach sectors, which have only arriving and departing traffic, form part of the ETMA. A specific distinction between arrival and departure sectors could be applicable in this case. Secondly, the ACC terminal sectors with a considerable amount of climbing and

descending traffic, but also in-cruise traffic are considered to be part of the ETMA airspace. The latter sectors are more similar to real En-Route sectors than the first.

So, in the ETMA both the specific TMA tools (AM/DM) and the specific En-Route tools (FPM, PS, CP) will be used, in addition to the generic TP. AM/DM will be used for arrival and departing traffic, the other tools will be used for ETMA-crossing in-cruise aircraft. In the adjacent En-Route sectors the En-Route specific tools will be used. The treatment of an in-cruise aircraft in a terminal sector is quite similar to the treatment of in-cruise aircraft in an upper En-Route sector, in which only tools such as FPM, CP and PS will be used.

However the AM/DM can have a radius of action that can extend beyond the ETMA boundary. For example, the AM/DM can provide constraints on the top of descent which could fall outside the ETMA for some flights.

Although it may differ for the second IOCP experiment, it has been decided to use the current Amsterdam TMA sector together with the Amsterdam ACC South sector as the ETMA sector under consideration. Furthermore, in the first IOCP ER/ETMA experiment, the focus is on arrival aircraft, so the DM PAT will not be used. In the second IOCP ER/ETMA experiment, trajectory negotiation will be supported by the NM PAT.

C.3.1.2 En-Route

En-Route sectors are considered to be sectors with mainly in-cruise flights, with a limited number of flights starting their descents or finishing their climbs. These are therefore usually the upper airspace sectors.

C.3.2 Operational Procedures

The basic operational procedures, which will be used within the ETMA and at the boundary of the ETMA and the adjacent en-route sector, will be derived from the OPS and OSD documents. These procedures can be split into three parts: (1) in-cruise traffic in the upper En-Route sectors, (2) in-cruise traffic in the En-Route sectors, which are part of the ETMA, and (3) departing and approaching traffic. The first and second group will be handled in the same way using En-Route specific tools, the third will be handled using TMA-specific tools such as the Arrival Manager.

During the simulation experiments of this IOCP, these operational procedures and their interrelation will be tested. Furthermore, the simulations should show if it is feasible to extend the En-Route concepts of "multi sector planning" and "4D-negotiation" for use within the (E)TMA.

C.3.2.1 Multi-sector planning

The concept of "multi sector planning" has been put forward within the ATM community as a means of increasing the capacity of air traffic control systems to accommodate the ever increasing growth in air traffic volumes. It will be the role of the IOCP of "En-Route multi- sector planning" to take the various proposals and to test them using an experimental environment.

Multi-sector planning seeks to reduce congestion and increase airspace capacity by the organisation of short/medium-term traffic flows on a somewhat larger scale, spanning several sectors or even centres, and by partial de-conflicting of traffic at (Multi-Sector) planning level.

During the conduct of this IOCP, the concept of "En-Route multi-sector planning being extended for use in an ETMA" will be taken into account. It is foreseen that for instance the AM will generate a preferred top of descent for aircraft that will be within either the ETMA or in adjacent the En-Route sector. Due to this sector-boundary crossing influence the resulting description of the interface between the ETMA and En-Route sectors should be closely related to the resulting En-Route multi sector planning procedures description.

C.3.2.2 4D-negotiation

The concept of "4D-negotiation" is potentially to be used in co-ordination with multi sector planning. In order to optimise the handling of the traffic at the ETMA/En-Route boundary and in the ETMA area, research must be done on how the concept of En-Route 4D-negotiation can be extended to be used in an ETMA. In particular departing traffic must be involved in the 4D-negotiation process in order to secure the foreseen benefits of multi sector planning.

One problem with planning around the moment of departure is that there is a considerable difference in precision before and after take-off. The predicted estimates before departure are sufficiently precise for traffic flow regulation of tactical ATFM, but certainly not for conflict-free planning. An inaccuracy of the precise moment of take-off of about 20 to 30 seconds of a T.B.D. look ahead time is an estimated minimum, with additional uncertainties due to e.g. platform movements. It should be noted that ground movement itself is outside the scope of this IOCP.

Despite the inaccuracy of the estimated time of departure, it is still valid that 4D-FMS equipped aircraft can make qualitatively better trajectory predictions than the ground systems, and that the ground systems can make better predictions, with respect to the behaviour on the different flight segments, when they have accurate flight status

data to their disposition. It is worthwhile therefore to exchange a predicted trajectory and flight status data between aircraft and ground system before departure. This can be used after take-off to support a trajectory negotiation process and it can be used to determine an estimate for the advised optimal time of departure.

After take-off a medium-term planning process can be started, when it is clear that no tactical actions are required in order to merge the aircraft in the assigned traffic flow. The departure Executive Controller or the sector Planner should take the initiative and inform the Multi-sector Planner of the opportunity for medium-term planning.

Following the outcome of the OTF this IOCP will therefore have to deal with the concept of trajectory negotiation within the ETMA. This negotiation process can be implemented, based on some premises:

- 1 The multi-sector planning concept will be introduced progressively, taking into account requirements concerning compatibility with traditional air traffic co-ordination concepts. New concepts therefore emerge in an evolutionary way from the present-day organization.
- 2 The man (the pilot as well as the ATCo) shall stay in the loop.
- 3 Just as for the IOCPs concerning "Human Centred Approach" and "En-Route multi sector planning", the concept of Trajectory negotiation can be based on a classical route structure.
- 4 The negotiation process will make use of the Negotiation Manager.

C.4 APPROACH AND METHOD TO CONDUCT THIS IOCP

C.4.1 Step by step approach



This IOCP shall be carried out in two steps. The first step concentrates on upgrading the ATC environment, so that it supports the operational procedures to be carried out for TMA, ACC and En-route controllers as specified in the OSD and OPS, without using the trajectory negotiation. This upgrading contains the integration of all PATs, except DM and NM, in NARSIM, and the introduction of air/ground and ground/ground data communications.

The second step, coinciding with the second IOCP ER/ETMA experiment will be based on the outcome of the first one. This step will extend the ATM functionality by introducing the multi-sector planning and 4-D air/ground trajectory negotiation concepts. For the support of this functionality, the NM PAT and the 4-D trajectory negotiation datalink application will be implemented.

Upon the outcome of each IOCP experiment, the operational procedures and the ATM functionality will be refined, if necessary. This will lead to new requirements to the OTF and the GHMI group. The updated deliverables of the OTF and the GHMI should be analysed again.

C.4.2 Co-ordination with GHMI

An important aspect in relation to the interface between ETMA and En-Route sectors is the support of the HMI to perform the necessary communications and planning activities. In close co-operation with the PHARE GHMI group, this IOCP will have to pay attention to amongst others, the following aspects:

-  Proper interactive options for communication, both for R/T and Data-link. The current means for R/T, combined with interactions with ATM systems, are not expected to change substantially, but for data-link communications the right interface has to be implemented. This should take into account work carried out in other projects, e.g. SWIFT, FANSTIC, PD/1 and PD/2.
-  Proper display aids are required:
 - Display of status information of messages exchanged by data-link.
 - Display of co-ordination information between sectors/centres
 - Feedback of communications interactions, e.g. to the flight plan processing.
 - History information.

The output of this IOCP will therefore be of importance for the definition of the requirements for the PD/3 GHMI

C.4.3 Scenario description

In order to test and adjust the operational procedures, provided by the OTF, a real-time simulation has to take place. Therefore one or more scenarios have to be developed. The traffic scenarios must be developed carefully since these could have important effects on the results and hence the conclusions of the studies. First the required scenario elements have to be identified. The simulated aircraft mix must be chosen, and the problems/scenario types to be simulated must be selected, including workload profiles. This will be followed by the implementation and testing of the scenarios.

The development of the several scenarios will be conducted in close co-ordination with the Dutch ATC, in order to get an idea of the current air-traffic situation which is as realistic as possible. The current air traffic in Europe can be split into 20% En-Route cruising traffic and 80% climbing/ descending traffic. Most of the current conflicts occur between both outbound and inbound air traffic of neighbouring ETMAs.

For example many conflicts occur between “outbound Amsterdam-Paris traffic” and the almost unpredictable “outbound traffic Eindhoven to London”. The characteristics of this outbound traffic require the possibility of a flexible simulation of each aircraft-type.

Similarly, “inbound Paris-Amsterdam” conflicts with “outbound Dusseldorf-London” and with inbound/outbound turboprop air-traffic of regional airports. Inbound air-traffic to Schiphol from the south area comprises 70% from the direction of Paris and 30 % from the direction of Luxembourg (A24).

With regard to en-route traffic two divisions must be made: the en-route turboprop aircraft which fly at flight level 200-250 and the en-route turbojet aircraft which fly at flight level 310 or above.

This IOCP will take into account the following controller positions: En-Route Planner and Tactical controller, ACC Planner and Tactical controller, TMA Planner controller (also known as Arrival Sequence Planner (ARR SP)), and a Multi-sector planner.

C.4.4 Testing of the IOCP

In parallel with the preparation of the simulations of this IOCP, the means and criteria for measurement of the proposed solutions will be specified. The VAL group will be consulted in order to obtain a consensus on the approach of the measurements. Due to the limited time-span and budget of this IOCP only a qualitative test of the results of the simulations is to be expected.

C.5 FACILITY OUTLINE DESCRIPTION.

C.5.1 Preparation of the simulation facilities.

It will be necessary to achieve the implementation of functionalities in the NLR real-time ATC Research Simulator (NARSIM) necessary for the conduct of such an experiment regarding the ETMA En-Route interaction.

A major task is to create a 4D flight and negotiation capability in the NARSIM airserver. Therefore requirements have to be defined, and 4D guidance capability and test criteria have to be specified, followed by design, implementation and testing.

Another major task is the integration of the PATs within the NARSIM client/server environment. For the first IOCP experiment, most of the PATs will be implemented.

There has to be a simple D/L capability. Preferably, PATN should be used for communication. PATN has to support the Downlink of Aircraft Parameters and 4D-trajectory negotiation air/ground applications. Next to this D/L capability, there has to be a simple R/T simulation capability.




Furthermore the meteo-model has to be extended with a flight level dependent wind-model.

C.5.2 Implementation of PATs or stubs





Various PATs have to be integrated in NARSIM through the CMS APIs. For the support of the first IOCP experiment, the following PATs will be implemented: AM, CP, FPM, HIPS, and TP. Before the second experiment, the NM will also be implemented to support the 4D-trajectory negotiation concept.

C.5.3 Controller working positions

The following controller working positions (CWPs) are needed to conduct the first simulation experiment of this IOCP:

-  One combined ER Planner / Tactical controller position
-  One combined ACC Planner / Tactical controller position
-  One Arrival Sequence Planner position

Most probably, the second experiment will include the following CWPs:

-  One combined ER Planner / Tactical controller position
-  One combined ACC Planner / Tactical controller position
-  One Arrival Sequence Planner position
-  One Multi-sector Planner position

Furthermore, two to four pseudo pilot positions are needed, which to control about 80 aircraft simulated at the same time.

C.6 PD/3 PARTNERS' INVOLVEMENT

C.6.1 Co-ordination with the "Human Centred Approach" IOCP

The conduct of this IOCP will be harmonized with the IOCP of "Human Centred Approach". Apart from the co-ordination with GHMI, with regard to the prototyping of the HMI of the PATs, the co-ordination with "Human Centred Approach" will be within the area of the operational use of these advanced tools by the human controllers. Information on the ER/ETMA IOCP will be distributed for review and comments to the team working on the HCA IOCP. Likewise documentation from the HCA IOCP will be reviewed by the ER/ETMA team.

C.6.2 Co-ordination with the "En-Route Multi-Sector Planning" IOCP

As mentioned in section C.3.2.1 There exists a direct relationship between this IOCP and the En-Route Multi-Sector Planning IOCP. Operational developments from that IOCP will therefore be taken into account where possible. Information on the ER/ETMA IOCP will be distributed for review and comments to the team working on the MSP IOCP. Likewise documentation from the MSP IOCP will be reviewed by the ER/ETMA team.

C.6.3 PD/3 Partners' involvement in this IOCP

NLR will conduct this IOCP. The PD/3 partners, CENA and EEC, NATS and DLR will be informed of its progress. Internal documentation will be made available to these partners for review and comment.

C.6.4 Dependencies

Achievement of the targeted results of this IOCP critically depends on the following:

- The successful adaptation of the NLR ATM Research Simulator (NARSIM) with the minimum required functionality for the execution of this IOCP.
- The availability of appropriate versions of the PATs: FPM, CP, (HI)PS, TP, AM/DM and NM.
- The availability of the PATN
- The availability of valid HMI implementations resulting from HMI prototyping activities by the GHMI project.
- The development and availability of the validation tools (VAL).
- The developments of the IOCP of "En-Route multi sector planning",
- The developments of the IOCP of "Human Centred Approach",
- The development of PATS functionality for PD/2.

C.7 REFERENCES

- [1] "PD/3 Demonstration Operational Specification", March 95,
Ref: PHARE/CENA/PD3-1.3.1/OPS;3.1, DOC 95-70-02
- [2] "PD/3 Operational scenario (OSD), draft, June 1996,
Ref: PHARE/CENA/PD3-1.1.3.2.2/WP1;1.0, DOC 96-XX-XX

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D.1 INTRODUCTION

This document is a description of the IOCP to be conducted by NATS Ltd within the PD/3 work programme. It follows a proposal presented at the PD3CG/15 meeting at CENA Athis-Mons on the 26th and 29th March. Section 2 gives a description of the aims and objectives of the proposed research. Section 3 provides details of the proposed work packages to achieve the aims and objectives. Section 4 gives a detailed work plan together with dates of deliverables to be produced. Section 5 provides a financial estimate of the proposed work.

D.2 RESEARCH AIMS AND OBJECTIVES

The PD/1 analysis carried out to date has shown that the introduction of computer assistance tools and datalink (PATS), along with their associated HMI, creates no significant decrease in controller workload relative to the baseline scenario. The analysis identified two themes which seem to be crucial in understanding exactly why the anticipated decrease in workload was not observed. These themes were:

- i) tool utilisation;
- ii) workload redistribution between controllers.

The PD/1 analysis identified that there were occasions when the PATS were not being used to their full envisaged functionality. This would obviously mask any real reduction in workload provided by the PATS. The reasons seem to be partly due to shortfalls in the PATS themselves, problems in the controller/PATS interface, a lack of understanding on the controllers' part of the full functionality of the PATS and shortfalls in the experimental design. The analysis identified examples of under-utilisation of the tools caused by:

- i) tool inflexibility;
- ii) frustration experienced by the controllers;
- iii) lack of controller confidence.

The PD/1 analysis also found that the workload of the tactical and planner roles was significantly altered by the introduction of the PATS. Although the operational demands on the controllers were the same with the introduction of PATS, the actual methods which they used to control the traffic changed.

Previous NATS' studies have identified similar under utilisation of computer assistance tools by controllers in real-time simulation studies. The NATS' funded Computer Assistance for En-Route (CAER) Trial experienced such under utilisation and was the subject of an investigation using the Performance and Usability Model for Air traffic management (PUMA) workload model (Reference 1). The study identified significant decreases in controller workload should be attainable given a change in the controllers' methods of working with the new tools.

There is also a need for a comparison of PD/1 with current day, en-route scenarios. The CAER study used a baseline scenario based on the New En-Route Centre (NERC Reference System - NRS). Since both trials used the same scenario, planner/tactical mode of operation and traffic samples, it is possible to conduct a direct comparison between the PD/1 results and the CAER-NRS results. A matched comparison is possible between the PD/1 and CAER trials for four of the British controllers who participated in both trials; in addition, results from LATCC controllers are available from the CAER study.

Hence the aims and objectives of the proposed work are to:

- i) compare PD/1 with a present day, en-route scenario;
- ii) continue PD/1 analysis to investigate more deeply the issues raised in the PD/1 analysis to date;
- iii) investigate the workload redistribution in PD/1;
- iv) conduct a small scale continuation of PD/1 on the NATS Research Facility (NRF) to test results of new analysis - this trial will be referred to as PD/1+;
- v) analyse the results of this new trial.

Much of the continued PD/1 analysis will be based on the PUMA workload modelling tool. PUMA is designed to enable the prediction of controller workload for any given ATC scenario. It enables the rapid determination of controller workload, given a particular way of working (an operational concept) and a particular airspace sectorization, route structure and traffic sample (a scenario). PUMA then allows initial investigations to:

- i) determine those areas of an operational concept which are particularly workload intensive;
- ii) quantify the effect on workload of proposed changes to the operational concept;
- iii) quantify the effect of different scenarios on controller workload.

The expected outputs from the proposed work are:

- i) a comparison of PD/1 with the CAER-NRS data;
- ii) to make an assessment of the expected change in workload of each of the individual PATS if the controllers were to employ them in the ideal manner;

- iii) to assess how the division of workload may be better organised between the two controller roles;
- iv) to assess the team effectiveness of this division of workload;
- v) to establish where areas of high workload may be reduced by the introduction of the PATS;
- vi) to make an assessment of the 'theoretical' expected change in workload if the controllers were to operate the complete system in an ideal manner;
- vii) to make recommendations for further development of the PATS and GHMI prior to, and following the PD/1+ trial, for incorporation into PD/3;
- viii) to make recommendations for controller training for PD/3.

D.3 WORK PACKAGES

Eight main work packages are proposed:

- WP0 Comparison of PD/1 with CAER-NRS data;
- WP1 Carry out PUMA analysis of PD/1;
- WP2 Prepare report of PUMA analysis;
- WP3 Conduct analysis of workload split between tactical and planner controllers;
- WP4 Minor development of the PD/1 PATS and GHMI and of the instructions given to controllers concerning task allocation between the roles;
- WP5 Prepare for PD/1+ trial;
- WP6 Conduct PD/1+ trial;
- WP7 Analyse results and make recommendations for PD/3.

D.3.1 Work package 0

WP0 will examine the workload recorded in the three PD/1 organisations compared to that previously recorded in a current day, NERC style operation. The outcome of this work will be an assessment of the improvement gained in all PD/1 organisations compared to a strip-based operational system. These results will be obtained early into the IOCP and will feed into the development of a baseline for PD/3.

D.3.2 Work package 1

The outcome of WP1 and WP2 is likely to recommend some development of the PATS and GHMI. This development will commence, in conjunction with the PATS and GHMI working groups, when the initial results from the PUMA analysis are known. The analysis of the workload split between the tactical and planner controllers (WP3) will be based both on the PD/1 data, which already exists, and also on the initial results from the PUMA analysis. This will predict the task allocations in the tactical/planner team that will create the lowest joint workload. The purpose of the proposed PD/1+ trial will be to test the predictions of WP1, WP2 and WP3 in a real trial situation. The following will be the main themes that the trial will test:

- i) to what extent can the optimum workload distribution between the tactical and planner controllers in PD/1 be achieved in practice and how much can workload be reduced;
- ii) to what extent can the theoretical predictions (from PUMA) of workload decrease be achieved in a real trial and why do differences occur.

WP1 is split up into the following areas:

- WP1a review existing PD/1 documentation;
- WP1b observational task analysis of PD/1 video tapes;
- WP1c define appropriate scenarios used (static and dynamic data);
- WP1d investigate the operational concepts in terms of their constituent events, tasks, actions and the individual workload;
- WP1e run simulation (generation of a log file of events, tasks, actions, channel loadings and the corresponding workload);
- WP1f analyse data.

D.3.3 Work package 2

The definition of WP2 is:

To establish where areas of high workload may be reduced by the introduction of PATS. To make an assessment of the expected change in workload of each of the individual PATS if the controllers were to employ them in an ideal manner. To make recommendations for further development of the PATS and GHMI prior to and following the PD/1+ trial, for incorporation into PD/3.

D.3.4 Work package 3

The definition of WP3 is:

To assess how the division of workload may be better organised between the two controller roles. To assess the team effectiveness of this division of workload. To make recommendations for further developments of the PATS and GHMI prior to, and following the PD/1+ trial for incorporation into PD/3.

D.3.5 Work package 4

The GHMI aspects of WP4 will be undertaken by NATS as WP5 in its participation in the PD/3 GHMI (Reference 2). The PATS changes will be undertaken by NATS in conjunction with the PATS project leader. The effort has been estimated as identical to that required for the GHMI modifications; however, any additional effort will have to be funded from the PATS project. Hence WP4 will consist of the following work packages:

- WP4a make minor changes to the PD/1 PATS which require modification;
- WP4b make minor changes to the PD/1 GHMI which requires modification;
- WP4c integrate these changes into the PD/1 elements of the PD/3 system.

D.3.6 Work package 5

In the proposed PD/1+ trials it is hoped to use controllers who participated in the original PD/1 trials to reduce resources spent on training. This will also help to eliminate controller unfamiliarity with the PATS as a factor from the experiment. There will be a recap on the envisaged functioning of the tools and clearer guidelines will be issued on the roles of the tactical and planner controllers. Clear guidance will be given on any changes to the PATS or GHMI made in WP4. Preparation for the PD/1+ trial will be composed of the following work packages:

- WP5a identifying participating controllers;
- WP5b form trial hypotheses to test;
- WP5c determine output requirements from trial to test these hypotheses;
- WP5d trial administration;
- WP5e change the PD/1 training instructions concerning task allocation between roles and the PATS/GHMI modifications.

D.3.7 Work package 6

The trial itself (WP6) will be held over four weeks. The trial will explore the two themes identified in section 2.1. In addition, it will also test ideas which emerge from the conclusions of WP1-WP3. Hence the predictions from the PUMA analysis will be tested concerning tool utilisation and workload distribution between the controllers. There may also be scope to measure learning effects by running some identical runs of trials with the same controllers and traffic samples. The trial will consist of the following work packages:

- WP6a controller training;
- WP6b feed sectors;
- WP6c trial observation and debriefing;
- WP6d maintenance and supervision of trial.

D.3.8 Work package 7

WP7 will consist of the following:

- WP7a analysis of the PD/1+ trial;
- WP7b produce report on the trial;
- WP7c make final recommendations to be used in PD/3.

D.3.9 Deliverables

The deliverables from this work are:

- D1 Report on WP0;
- D2 Working Paper on the PUMA Analysis of PD/1 i.e. WP1;
- D3 Working Paper assessing the impact on workload of tool support for key controller tasks, the degree to which the individual tasks could be undertaken more optimally through changes in action sequence, duration and channel loadings and containing recommendations for further development of the PATS and GHMI prior to and following the PD1+ trial. I.E. WP2;
- D4 Working Paper, proposing how the division of workload may be better organised between the two controller roles, assessing the team effectiveness of this proposed division of workload, and containing recommendations for further development of the PATS and GHMI prior to and following the PD/1+ trial.
- D5 Report on the PD/1+ trial.
- D6 Recommendations of the PD/1 enhancements to be incorporated into PD/3.

D.4 REFERENCES

- [1] "Initial results on the effects of Computer Assistance tools upon controller workload."; CS 9503; P Houselander S Owens; Jan 1995
- [2] "NATS participation in PD/3 GHMI", A Lucas, May 1996

Annex E: Responsibilities in PD/3

Role	Responsible
PD/3 Project Leader	Marc Bisiaux., EEC
OTF chairman	Jean-Pierre Nicolaon, EEC
PD/3 Local Project Leader EEC	Robert Graham
PD/3 Local Project Leader NLR	Wim Post
PD/3 Local Project Leader CENA	Jean-Louis Martin
PD/3 Local Project Leader NATS	Rob Whitaker
PD/3 Local Project Leader DLR	Helmut Niederstrasser

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Annex F: Task Descriptions

Note : This Annex gives the PD/3 top level task descriptions associated with the Gantt chart definition in annex G.

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Annex G: Gantt Chart

Note: This Annex is a top level version of the PD/3 Gantt chart reflecting the situation at PMB/19A in February 1997.

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